CLAIMS

1. A method of sorting cells comprising:

providing a fluid flow path for cell movement through a series of cell sorters in a first direction with an output of a preceding cell sorter of the series communicating with an input of a successive cell sorter of the series;

separating, within each cell sorter, a first portion of the cells from a second portion of the cells by applying a first non-uniform electric field via a first electrode array to cause movement of the first portion of the cells in a second direction across the fluid flow path, having a component generally transverse to the first direction into the output of a respective cell sorter;

wherein separating the first portion of the cells from the second portion of the cells further includes at least one of:

applying the first non-uniform electric field as a temporally varying non-uniform electric field at a different frequency in at least two cell sorters of the series;

interposing the fluid flow path in each cell sorter between the first electrode array and a second electrode array, and applying a second temporally varying non-uniform electric field from the second electrode array to cause transport of the cells along the fluid flow path in the first direction; and

applying the first non-uniform electric field as a plurality of discrete non-uniform electric fields successively applied at different positions along the fluid flow path.

2. The method of claim 1 wherein the first portion of the cells are target cells to be collected and the second portion of the cells are non-target cells to be discarded.

3. The method of claim 1 wherein the second portion of the cells are target cells to be collected and the first portion of the cells are non-target cells to be discarded.

4. The method of claim 1 wherein applying the first non-uniform electric field as a first temporally varying non-uniform electric field comprises:

applying a first frequency at a first cell sorter of the at least two cell sorters of the series, wherein the first frequency corresponds to a frequency at which the first portion of the cells and a third portion of the cells respond to the electric field with movement in the second direction and at which the second portion of the cells responds substantially less to the electric field with movement in the second direction; and

applying a second frequency at a second cell sorter of the at least two cell sorters of the series, wherein the second frequency corresponds to a frequency at which the first portion of the cells respond to the electric field with movement in the second direction and at which the third portion of the cells responds substantially less to the electric field with movement in the second direction.

5. The method of claim 1 wherein applying the first non-uniform electric field as a first temporally varying non-uniform electric field comprises:

applying the temporally varying non-uniform electric field at a different frequency in three or more cells sorters, wherein the different frequency in each cell sorter corresponds to a frequency at which the first portion of cells responds to the electric field with movement in the second direction and at which at least one of a plurality of portions of the cells, including the second portion of the cells, responds substantially less to the electric field with movement in the second direction.

6. The method of claim 1 wherein interposing the fluid flow path between the first electrode array and the second electrode array comprises:

arranging the first electrode array as a plurality of electrode elements generally parallel to each other in a spaced relationship with each electrode element generally parallel to a longitudinal axis of the fluid flow path;

arranging the second electrode array as a plurality of electrode elements generally parallel to each other in a spaced relationship with each electrode element generally perpendicular to the longitudinal axis of the fluid flow path; and

wherein interposing the fluid flow path between the first electrode array and the second electrode array comprises vertically disposing the first electrode array relative to the second electrode array with the fluid flow path disposed between the first electrode array and the second electrode array.

7. The method of claim 1 further comprising:

applying the first temporally varying non-uniform electric field alternately with applying the second temporally varying non-uniform electric field.

8. The method of claim 1 wherein the first temporally varying non-uniform electric field has a first operating frequency and the second temporally varying non-uniform electric field has a second operating frequency different than the first operating frequency.

9. The method of claim 1 wherein applying the first non-uniform electric field as a plurality of discrete non-uniform electric fields comprises:

applying the plurality of discreet non-uniform electric fields with each field applied from an end of an electrode element of a plurality of electrode elements spaced from each other and generally parallel to each other to cause movement of each cell of the first portion of the cells in the second direction relative to the end of the electrode element, wherein each electrode element is orientated generally parallel to the second direction

10. The method of claim 9 wherein applying the plurality of non-uniform electric fields comprises:

applying the plurality of non-uniform electric fields successively at points located closer to a second side of the fluid flow path.

11. A cell sorter system for a biodevice comprising:

a plurality of cell sorters arranged in series with each cell sorter including:

a fluid flow path for the passage of cells in a first direction; and

an electrode array configured to apply a temporally varying electric field to the cells to move the cells in a second direction having a component generally transverse to the first direction to cause separation of a first portion of the cells into a first port and a second portion of the cells into a second port,

wherein the electrode arrays within at least two cell sorters in the series are configured for operation at different frequencies and the first port of a preceding cell sorter in the series is in communication with an input of a subsequent cell sorter in the series.

12. The cell sorter system of claim 11 wherein the different frequencies for the electrode arrays of the at least two cell sorters comprise a first frequency and a second frequency with the first portion of the cells in each of the at least two cell sorters responding to the electric field with movement in the second direction and the second portion of the cells in each of the at least two cell sorters responding substantially less to the electric field.

13. The cell sorter system of claim 11 wherein the first portion of the cells is a target group of cells and the second portion of the cells is a non-target group of cells.

14. The cell sorter system of claim 11 wherein the second portion of the cells is a target group of cells and the first portion of the cells is a non-target group of cells.

15. The cell sorter system of claim 11 further comprising:

a signal generator in communication with the electrode array of each cell sorter and configured to apply a first frequency to a first cell sorter of the plurality of cell sorters, a second frequency to a second cell sorter of the plurality of cell sorters, and a third frequency to a third cell sorter of the plurality of cell sorters.

16. The cell sorter system of claim 11 further comprising:

a cell diverter disposed within the fluid flow path of each cell sorter and configured for separating the first portion of the cells into the first port and the second portion of the cells into the second port.

17. A cell sorter system for a biodevice comprising:

a plurality of cell sorters arranged in series with at least one cell sorter of the series including:

a fluid flow path configured for directing a flow of cells in a first direction;

an electrode arrangement including a first electrode array and a second electrode array with the first electrode array configured to apply a first temporally varying non-uniform electric field for causing movement of a field-responsive portion of the cells in a second direction having a component generally transverse to the first direction and the second electrode array configured to apply a second temporally varying non-uniform electric field for causing transport of the cells along the fluid flow path in the first direction; and

a cell diverter disposed within the fluid flow pathway to encourage separation of the field-responsive portion of the cells from a non-responsive portion of the cells.

18. The cell sorter system of claim 17 wherein each cell sorter in the series comprises the fluid flow path, the electrode arrangement, and the cell diverter.

19. The cell sorter system of claim 17 wherein the first electrode array and the second electrode array are vertically disposed relative to one another on opposite sides of the fluid flow path.

20. The cell sorter system of claim 17 wherein each of the first electrode array and the second electrode array comprise:

a plurality of electrode elements arranged generally parallel to each other with a long axis of each electrode element generally perpendicular to movement of the cells caused by the first and second electrode arrays, and wherein the plurality of electrode elements of each of the first and second electrode arrays are arranged with selective electrode elements connected together to define independently drivable sets of electrode elements.

21. The cell sorter system of claim 17 wherein the second electrode array extends from a main portion of the fluid flow path into and through a first port of the fluid flow path, and into and through a second port of the fluid flow path.

22. A cell sorter system for a biodevice comprising:

a plurality of cell sorters arranged in series with each cell sorter including:

a fluid flow pathway configured for directing a flow of cells in a first direction;

an electrode arrangement configured for causing movement of a first portion of the cells in a second direction generally transverse to the first direction by successive discrete movements of the first portion of the cells in the second direction; and

a cell diverter disposed within the fluid flow pathway to encourage separation of the first portion of the cells from a second portion of the cells.

23. The cell sorter system of claim 22 wherein the electrode arrangement comprises:

a first electrode structure including an array of spaced electrode elements arranged in series along a first side of the fluid flow path; and

a second electrode structure disposed on a second side of the fluid flow path and spaced from the first electrode structure;

wherein the first and second electrode structures are configured to apply a plurality of non-uniform electric fields with each non-uniform electric field applied between a separate electrode element of the first electrode structure and the second electrode structure.

24. The cell sorter system of claim 23 wherein at least some of the electrode elements extend further into the fluid flow path than other of the electrode elements.

25. The cell sorter system of claim 23 wherein each electrode element has a generally sharpened end from which the electric field is applied.

26. The cell sorter system of claim 23 wherein the electrode elements are generally parallel to each other and generally parallel to the second direction.

27. A cell sorter chip comprising:

means for transporting cells along a fluid flow path in a first direction; and

means for separating a target cell population from a non-target cell population through successive sorting operations along the fluid flow path with each sorting operation including a first non-uniform electric field to cause field-responsive cells to move in a second direction having a component generally transverse to the first direction,

wherein means for separating includes at least one of:

means for applying the first non-uniform electric field as a first temporally varying non-uniform electric field at a different frequency in each successive sorting operation;

means for applying a second temporally varying non-uniform electric field adjacent to the first non-uniform electric field to act as the means for transporting cells and means for applying the first non-uniform electric field as a temporally varying non-uniform electric field; and

means for applying the first non-uniform electric field as a plurality of discrete non-uniform electric fields successively applied at different positions along the fluid flow path.